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Testate Amoebae (Rhizopoda, Testacea) in Some Canadian Rocky Mountain Soils

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Summary

Information is presented on the species composition and distribution of Testacea in some soils of the Kananaskis Valley of the Rocky Mountains of Alberta, Canada. Forty-seven species and varieties are listed for 8 different habitats, with most of the species being new records for western Canada and the Rocky Mountains.

A. Introduction

There have been very few studies of Testacea in Canada. Most of the information available is from studies of Testacea in fresh-water habitats (Odell 1905; Wailes 1925, 1927, 1928, 1929, 1930a, b, c, 1931a, b, c, 1932, 1933) or in mosses (Fantham and Porter 1945). Records of soil and litter Testacea are even more scarce. Sandon (1927, 1928) listed 8 genera and 9 species from 10 soil samples from eastern Canada. In a more extensive work, de Puytorac et al. (1972) inventoried 28 genera and 121 species of Testacea from soils north of Montreal, Québec. Bonnet (1974) listed 42 genera and 143 species, including those given in de Puytorac et al. (1972), for 295 samples taken mostly from Québec, with a few from Ontario and Saskatchewan.

Ecological references for Canada in soil and litter Testacea are also few in number. Bonnet (1974) discussed biogeographic, biocenotic and ecological aspects of testacean distribution and he defined 16 species associations for Testacea from the various biotopes sampled in Canada. Lousier (1975) considered the relationships between the distribution of Testacea and the soil-litter habitat and vegetation in some Rocky Mountain soils. Lousier (1974a, b) described quantitatively the responses of testacean species to experimental moisture fluctuations in a Rocky Mountain deciduous forest and developed a method of calculating secondary productivity of soil and litter Testacea.

Edmondson (1912), Leidy (1877) and Penard (1891) listed Testacea in freshwaters of areas in the American Rocky Mountains and Cockerell (1909, 1911) listed a few soil Testacea from mountain areas in Colorado. Because mountain topography can provide a great variety in vegetation and soil types, the Rocky Mountains offer opportunities for the analysis of testacean communities, ranging from high alpine communities to those of the lower forests and valley floors. This paper is the first detailed record for Testacea in some Canadian Rocky Mountain soils, giving species recorded, test dimensions, and species distribution in 8 different habitats.

B. The Study Area

Location

The research was carried out in the Kananaskis Valley (ca. 51°2′N, 115°1′W), fifty miles west of Calgary, Alberta. The area encompasses the confluence of the foothills and the front range of the Rocky Mountains. The habitats studied were chosen from the Kananaskis Research Forest, Bow Forest Reserve and Marmot Creek Watershed Research Basin.

Climate

The climate of the region is essentially continental and is characterized by short, dry summers and relatively long, cold winters with intermittent warm chinook winds. Late July — early August is usually the warmest with a mean maximum temperature of between 10 and 15 °C, and January is usually the coldest month with a mean maximum of between − 5 and − 20 °C. About 50 % of the precipitation falls as snow and maximum precipitation falls in the three months of May, June and early July. The annual total ranges from 59.56 cm at the valley bottom to 104 cm on the higher slopes (KIRBY and OGILVIE 1969). The average frost-free period is approximately 58 days extending from about mid-June to near the end of August (DUFFY and ENGLAND 1967; KIRBY and OGILVIE 1969).

The ground remains frozen from early November to early April at the lower altitudes and to May and June at the higher altitudes. Winter soil temperatures at 1—10 cm depths vary from − 0.5 °C to − 6 °C whereas summer temperature could be as high as 25 °C at 1—2 cm depths. The climate of this sub-alpine forest region is considered to favour podzolization (HALLIDAY 1937). The climate and physical descriptions of the area have been well described and summarized in KIRBY (1973).

Sampling Sites

Eight sampling sites, one in each of the following habitats, fen mosses (other than *Sphagnum*), fen *Sphagnum*, spruce forest, pine forest, *Phyllodoce* alpine meadow, *Kobresia* alpine meadow, grassland and aspen woodland were selected. Brief site descriptions are given in Table 1 and soil profile descriptions are listed in LOUSIER (1975). The references used for plant identification were MOSS (1959), CORMACK (1967), WEBER (1967), BIRD (1968), POHL (1968), HALE (1969), HOSIE (1969) and PRESCOTT (1969).

C. Methods

The soil cores taken were separated into layers and cultures (after HEAL 1964) were established with 0.5 g samples from each organic soil layer. Living Testacea were studied in these cultures and also individually in a drop of water covered with a cover slip on a depression microscope slide. Fixed and stained specimens were studied on permanent slides prepared according to CÔUTEAUX (1967). These slides were used also for quantitative community analysis (LOUSIER 1975). The literature used for identification of Testacea included BONNET and THOMAS (1960), DECLOITRE (1961, 1962),

Table 1. Description of the 8 sampling sites

Site	Altitude	Soil Reference[1])	No. of spp. Testacea	Representative Vegetation
1. Fen (mosses)	1400 m	Hydric humisol organic	37	*Campylium stellatum* (Hedw.) C. Jens., *Tomenthypnum nitens* (Hedw.) Loesek; *Betula occidentalis* Hook.; *Equisetum* spp.; *Epilobium angustifolium* L.
2. Fen (*Sphagnum*)	1400 m	Hydric humisol organic	22	*Sphagnum warnstorfianum* Du Rietz, *S. magellanicum* Brid.; *Betula occidentalis*; *Equisetum* spp.
3. Spruce forest	1890 m	Ortho humo-ferric podzol	18	*Picea engelmannii* × *P. glauca* A. Dietr., *Abies lasiocarpa* (Hook.) Nutt.; *Menziesia ferruginea* Smith, *Vaccinium* spp.; *Lycopodium annotium* L., *Hylocomium splendens* (Hedw.) B.S.G.
4. Pine forest	1400 m	Mini humo-ferric podzol	21	*Pinus contorta* Dougl., *Abies lasiocarpa*, *Picea engelmannii* × *P. glauca*; *Salix* sp.; *Aster lindleyanus* Lindl., *Galium boreale* L.; *Agropyron* sp., *Danthonia* sp., *Bromus* sp.
5. *Phyllodoce* meadow	2590 m	Lithic regosol	14	*Phyllodoce glanduliflora* (Hook.) Cov., *P. empetriformis* (Sm.) D. Don., *Cassiope mertensiana* (Bong.) G. Don, *C. tetragona* (L.) D. Don
6. *Kobresia* meadow	2500 m	Lithic dark brown chernozemic	18	*Kobresia myosuroides* (Vill.) Fiori and Paol., *Elymus innovatus* Beal, *Dryas hookeriana* Juz., *Potentilla nivea* L.; *Tortula ruralis* (Hedw.) G. M. and S., *Cetraria* spp.
7. Grassland	1460 m	Orthic dark brown chernozemic	17	*Agropyron* sp., *Danthonia* sp., *Bromus* sp., *Phleum* sp.; *Dodecatheon conjugens* Greene, *Galium boreale*, *Delphinium bicolor* Nutt., *Campanula rotundifolia* L.
8. Aspen woodland	1400 m	Orthic gray luvisol	27	*Populus tremuloides* Michx., *P. balsamifera* L., *Pinus contorta*; *Thalictrum venulosum* Trel., *Rosa acicularis* Lindl., *R. woodsii* Lindl., *Epilobium angustifolium*, *Castilleja miniata* Dougl.; *Agropyron* sp., *Danthonia* sp., *Bromus* sp.

1) Soil references: Soils in sites 1, 2, 3, 4, 5, 8 — Karkanis (1972).
Soil in site 6 — Kirby and Ogilvie (1969) and Karkanis (1972).
Soil in site 7 — Lousier (1972).
The soils are classified according to "The System of Soil Classification for Canada", Ottawa 1970.

Table 2. Testacea observed in 8 habitats in the Alberta Rocky Mountains

Species of Testacea	Distribution*				Observed	Dimensions (μm)**
	A_0L	A_0F	A_0H	Ah	pH	
Superclass Sarcodina HERTWIG and LESSER 1875						
Class Rhizopoda von SIEBOLD 1845						
Subclass Lobosia CARPENTER 1861						
Order Testacealobosa DE SAEDELEER 1934						
Suborder Eulobosa						
Family Arcellidae EHRENBERG 1830						
Arcella catinus PENARD, 1902	1, 2, 3, 4, 6, 7	4, 5, 6, 7, 8	6		6.3–6.9	D: 83–105; H: 20–35; Pd: 20–22; or: 10–15
A. discoides EHRENBERG, 1871	1, 2	1, 2	1,2	1	6.4–6.7	D: 120–127; H: 25–27; Pd: 45–48; or: 9–12
A. discoides var. *scutelliformis* PLAYFAIR, 1918	1	1			6.4–6.7	D: 50–80; H: 20–27; Pd: 17–28; or: 8–11
A. megastoma PENARD, 1902	1				6.6	D: 245; H: 47–50; Pd: 80–89; or: 10–11
Family Centropyxidae DEFLANDRE, 1953						
Centropyxis aculeata (EHRENBERG) STEIN, 1857 sec. PENARD, 1902	1				6.6	Ds: 145–195; D: 129–145; Pd: 35–53; H: 31–45
C. aerophila DEFLANDRE, 1929	1, 2, 3, 4, 5, 6, 7, 8	1, 2, 3, 4, 5, 6, 7, 8	1, 2, 3, 4, 5, 6, 7, 8	2, 6	6.4–7.2	L: 50–80; W: 40–65; P: 20–25 × 14–18
C. aerophila var. *sphagnicola* DEFLANDRE, 1929	1, 2, 3, 4, 5, 6, 7, 8	2, 3, 4, 5, 6, 7, 8	1, 3, 4, 6, 7, 8	2, 6, 7	6.4–7.2	D: 45–60; H: 25–30; P: 20–32
C. sylvatica (DEFLANDRE) THOMAS, 1955	1, 3, 4	3, 4, 8	8		6.4–7.2	L: 86–102; W: 70–87; P: 21–29 × 40–57
Centropyxis cassis (WALLICH) DEFLANDRE, 1929			8		6.7	L: 60–70; W: 48–60; H: 32–38; P: 18–24 × 40–50

C. discoides (PENARD) DEFLANDRE, 1929		1			6.4	D: 195–205; H: 35; Pd: 60–65
C. minuta DEFLANDRE, 1929	3, 6	1, 2, 3, 4, 7, 8	2, 4, 5, 6, 7, 8	5, 6, 7	6.4–7.2	D: 40–60; H: 30–38; Pd: 12–30
C. plagiostoma BONNET and THOMAS, 1955		4	3, 4, 8	3, 4, 6	6.5–7.2	D: 65–90; H: 38–45; P: 12–18 × 18–27
C. platystoma (PENARD) DEFLANDRE, 1929	3	3	1, 2, 3, 8		6.7–7.2	L: 45–65; W: 25–35; H: 25–30; Pd: 17–25
Cyclopyxis eurystoma DEFLANDRE, 1929	6, 8	1, 6, 7, 8	1, 2, 4, 6, 7, 8	1, 2, 4, 6	6.4–6.8	D: 45–63; H: 32–46; Pd: 24–33; or: 3–6
C. eurystoma var. *gauthieriana* BONNET and THOMAS, 1960			6, 8	6, 8	6.6–6.7	D: 75–80; H: 56–60; Pd: 41–44; or: 7–10
C. kahli DEFLANDRE, 1929	8	6, 7, 8	1, 2, 5, 6, 7	2, 6	6.6–7.0	D: 80–100; H: 53–60; Pd: 24–30; or: 13–41
Family Plagiopyxidae BONNET 1950						
Plagiopyxis callida PENARD, 1910		5, 8	6, 8	5, 6, 7, 8	6.5–7.0	L: 65–87; W: 70–93; $\bar{D}$: 85
Family Nebelidae TARANEK 1882						
Subfamily Nebelinae DELFANDRE, 1953						
Hyalosphenia elegans LEIDY, 1879	1, 2	1, 2	1		6.4–6.8	L: 86–135; W: 40–68; T: 22–34; Pd: 20 (outer), 8–9 (inner)
H. minuta CASH, 1891	2		1, 4, 8		6.4–7.0	L: 32–40; W: 20–25; T: 10–12; P: 12–15
H. subflava CASH, 1909	1, 2, 8	2, 8	1, 2, 8		6.4–6.8	L: 45–73; W: 31–50; T: 19–26
Nebela collaris (EHRENBERG) LEIDY, 1879		1			6.6	L: 110–190; W: 60–105; T: 34–60; P: 23–32 × 14–22
Nebela dentistoma PENARD, 1890		1			6.6	L: 112–115; W: 90
N. lageniformis PENARD, 1890		1			6.6	L: 115–150; W: 70–89; P: 25–36
N. nobilis (CASH) DEFLANDRE, 1936		1			6.6	L: 170–190; W: 87–88; P: 30
Heleopera petricola LEIDY, 1879	1, 8	1, 2, 3	2		6.4–6.8	L: 75–130; W: 60–80; T: 40–53; P: 47–52 × 12–14
H. petricola var. *major* CASH, 1909	1				6.4	L: 130–135; W: 80; T: 65; P: 60 × 15

Table 2 (cont'd)

Species of Testacea	Distribution*				Observed	Dimensions (μm)**
	A_0L	A_0F	A_0H	Ah	pH	
Quadrulella symmetrica var. *longicollis* TARANEK, 1882			1		6.6	L: 105–135; W: 55–85; T: 32–42; P: 25–30 × 10–13
Subfamily *Paraquadrulinae* DEFLANDRE, 1953						
Paraquadrula irregularis (ARCHER) DEFLANDRE, 1953			1		6.6	D: 33–38; P: 12
Suborder Reticulobosa						
Phryganella acropodia (HERTWIG and LESSER) HOPKINSON, 1909	1, 3, 4, 5, 6, 7, 8	1, 2, 3, 4, 5, 6, 7, 8	1, 2, 3, 4, 5, 6, 7, 8	1, 2, 3, 4, 5, 6, 7	6.4–7.2	D: 33–52; H: 25–43; P: 15–27
Difflugiella oviformis (PENARD) BONNET and THOMAS, 1955	1, 2, 5, 6, 7	1, 2, 3, 4, 5, 6, 7, 8	1, 2, 3, 4, 5, 6, 7, 8		6.4–7.2	L: 15–25; D: 8–15; P: 3–5
Subclass Filosia LEIDY 1879						
Order Testaceafilosa de SAEDELEER 1934						
Family Euglyphidae WAILES 1919 amend.						
Assulina muscorum GREEFF, 1888	4	4, 8	1		6.6	L: 30–60; W: 20–50; P: 8–15
A. seminulum (EHRENBERG) LEIDY, 1879	4	8	1		6.4	L: 65–96; W: 50–80; P: 17–27
Corythion dubium TARANEK, 1881	3, 4	3, 4			6.4–7.2	L: 35–60; W: 25–38
Trinema enchelys (EHRENBERG) LEIDY, 1878	1, 2, 3, 4, 6, 8	1, 2, 3, 4, 5, 6, 7, 8	1, 2, 3, 4, 5, 6, 7, 8	2, 3, 4, 5, 6, 8	6.4–7.2	L: 40–85; W: 22–45
T. lineare PENARD, 1890	1, 2, 3, 4, 5, 6, 7, 8	1, 2, 3, 4, 5, 6, 7, 8	1, 2, 3, 4, 5, 6, 7, 8	3, 4, 5, 6, 8	6.4–7.2	L: 23–40; W: 10–20
Euglypha scutigera PENARD, 1911	1, 2, 3, 4	1, 3, 4, 5	5, 6, 7	6, 8	6.4–6.8	L: 70–90; W: 45–50; P: 12–24; pl: 10–12 × 8–10
E. tuberculata DUJARDIN, 1841	4	4			6.4–6.6	L: 60–90; W: 28–45; P: 14–17; pl: 10–14
E. rotunda WAILES and PENARD, 1911	1, 2, 3, 4, 5, 6, 7, 8	1, 2, 3, 4, 5, 6, 7, 8	1, 2, 3, 4, 5, 6, 7, 8	4, 5, 6, 8	6.4–6.9	L: 22–55; W: 10–20; P: 8–15; pl: 5–8 × 2–4

E. laevis (Ehrenberg) Perty, 1849	1, 2, 3, 4, 5, 6, 7, 8	1, 2, 3, 4, 5, 6, 7, 8	2, 4, 5, 6, 7, 8	4, 5, 6	6.4–6.9	L: 20–60; W: 12–35; P: 5–18
E. polylepis (Bonnet) Bonnet and Thomas, 1960	5, 6, 7	5, 6, 7	7, 8	6	6.5–6.8	L: 55–65; W: 30–40; T: 20–30; P: 15–22 × 8–12; pl: 5 × 2
E. strigosa (Ehrenberg) Leidy, 1879	1, 2	1, 2	2		6.4–6.8	L: 65–85; W: 46–56; T: 22–25; P: 15–19; pl: 7–10 × 4–5; sp: 15 to 20
E. strigosa forma *glabra* Walies, 1915	1, 2	1, 2, 6, 7	2		6.4–6.8	L: 65–85; W: 46–56; T: 22–25; P: 15–19; pl: 7–10 × 4–5
E. ciliata (Ehrenberg) Leidy, 1879	1	1			6.4–6.6	L: 60–90; W: 40–60; T: 25–35; P: 15–23 × 10–16; sp: 8–10
E. ciliata forma *glabra* Wailes, 1915	1	1			6.4–6.6	L: 60–90; W: 40–60; T: 25–35; P: 15–23 × 10–16
E. compressa Carter, 1864	1, 2, 3, 4, 8	1, 2, 3, 4, 8			6.4–7.2	L: 75–117; W: 42–70; T: 20–38; P: 20–35; pl: 9–12; sp: 5–15
Euglypha compressa forma *glabra* Wailes, 1915	1, 2, 3, 4, 8	1, 2, 3, 4, 8	1		6.4–7.2	L: 75–117; W: 42–70; T: 20–38; P: 20–25; pl: 9–12
Family Cyphoderiidae Deflandre 1953						
Cyphoderia ampulla (Ehrenberg) Schlumberger, 1845	1	1			6.4–6.8	L: 80–140; W: 25–65; P: 10–20

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*Distribution: 1 Fen mosses; 2 Fen *Sphagnum*; 3 Spruce forest; 4 Pine forest; 5 *Phyllodoce* alpine meadow; 6 *Kobresia* alpine meadow; 7 Grassland; 8 Aspen woodland.

**Dimensions: D: diameter; $\bar{D}$: mean diameter; Ds: diameter with spines; H: height; T: thickness; L: length; W: width; P: pseudostome; Pd: pseudostome diameter; or: oral invagination; pl: platelets; sp: spines.

DEFLANDRE (1928, 1929, 1932, 1936), GROSPIETSCH (1958, 1965), LEIDY (1878, 1879), PENARD (1890, 1902) and THOMAS (1958).

D. Testacea in Kananaskis Soils

The Testacea observed in the 8 Kananaskis Valley soils are listed in Table 2. Forty-seven species and varieties of soil Testacea were observed, with most being new records for western Canada and Rocky Mountain soils. Nine species (*Trinema lineare, T. enchelys, Euglypha laevis, E. rotunda, Phryganella acropodia, Corythion dubium, Assulina muscorum, Centropyxis aerophila, C. aerophila* var. *sphagnicola*) comprised 80% of the individuals examined, with *T. lineare, T. enchelys, E. laevis, E. rotunda. P. acropodia, C. aerophila* and *C. aerophila* var. *sphagnicola* almost completely ubiquitous, *C. dubium* limited, and *A. muscorum* very restricted in distribution. Relationships between the Testacea recorded and the vegetation and soil type are given in LOUSIER (1975).

There were no problems encountered in using European taxonomic literature for the identification of Rocky Mountain Testacea. However, there were some significant differences noted between the test size and morphology observed and the test information given in the literature. Of those species showing the greatest differences from the literature descriptions, not enough specimens were observed to describe new varieties or possibly new species. These species included *Arcella catinus, A. megastoma, Centropyxis aculeata, Nebela collaris, N. dentistoma, N. lageniformis, N. nobilis* and *Cyphoderia ampulla*. Detailed descriptions of the species observed are given in LOUSIER (1972) and may be obtained from the author.

This similarity of testate faunas observed in Canada to those observed in Europe (SANDON 1928; FANTHAM and PORTER 1945; DE PUYTORAC et al. 1972; BONNET 1974) attests further to the generally cosmopolitan character of the testacean fauna. STOUT and HEAL (1967) cited the genetic stability of testacean species as being more important than widespread physical distribution (by birds, insects or wind) in maintaining homogeneity amongst species of Testacea.

This inventory can serve only as an introduction to testacean research in Rocky Mountain soils because of the lack of research in the area, and because there are very few detailed ecological references for soil Testacea. Most records are for freshwater and mosses of varying degrees of wetness. There has been some documentation of the soil and litter habitats of a few species of Testacea (e.g., BONNET and THOMAS 1960) but most work is incomplete and in some cases inadequate. Consequently most ecological information available for most species is generalized and sometimes vague, and the geographic distribution is not yet widely known for many species. The ecological observations in this study confirm, contradict or in most cases, extend the previous observations in the literature. This study has brought ecological observation down to the soil layer level in the various habitats and provides new references for the species studied. However, further habitat-type, vegetation and pedological investigations will be necessary before an adequate account of the distribution of Testacea in the Rocky Mountains can be produced.

Zusammenfassung

Es wird eine Übersicht über die Artzusammensetzung und die Verteilung der Testaceen in einigen Böden des Kananaskis-Tales in den Rocky Mountains von Alberta, Kanada, gegeben. 47 Arten und Varietäten aus 8 verschiedenen Biotopen wurden listenmäßig erfaßt, wobei die meisten Arten erstmalig für Westkanada und die Rocky Mountains gemeldet wurden.

Résumé

L'auteur present la distribution et la composition faunistique dans thécamoebiens de quelques sols de la Vallée Kananaskis dans les Montagnes Rocheuses de l'Alberta, Canada. 47 espèces et variétés de thécamoebiens du sol ont été inventoriées dans 8 habitats différents, avec la plupart des espèces étant nouvelles pour l'ouest canadien et les Montagnes Rocheuses.

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